A Single-Authoring and Bridging Framework for Virtual and Augmented Reality Interfaces

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ABSTRACT
Although Image-Plane techniques have been associated with user fatigue and selection ambiguity problems, they can act as a bridging strategy between 2D desktop and 3D immersive environments. We introduce a framework that facilitates such transitions by using Image-Plane techniques with a virtual cursor visible only in the dominant eye on 2D interfaces below the hand of the user. We have developed a proof of concept virtual world building application for the Ygdrasil authoring platform that demonstrates our framework. We propose that this framework facilitates the authoring and utilization of 3D user interfaces in general by leveraging existing computer skills, reinforcing the interface in the 2D environment and unifying the development effort for both platforms.

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Keywords: Through the Lens, Image Plane, Augmented Reality

1 INTRODUCTION

Much of the research into 3D user interfaces appears to make several assumptions about their users. First, it is broadly assumed that users will tolerate a significant increase in physical exertion over the desktop systems that they use today. Secondly, it is commonly assumed that any number of unique interaction tools will be required for 3D interfaces. Both these lines of thinking are exemplified by the recent trend towards tangible or transitional interfaces. Yet, it is well understood that users seek the most productivity at the least physical cost and that the success of desktop systems as efficient work environments can be attributed to the adoption of a single canonical device mediating the interface. Finally, an implicit assumption of 3D interface designers is that the context is so compelling that users will tolerate the lack of functions found on the average home computer. Yet, certainly it is not unreasonable to consider the 3D user interface as a superset of any 2D interface; the former having more functionality than the latter.

Unfortunately, much of the underlying research on 3D user interfaces does not rely on the assumption that users will make a gradual transition from desktop machines to larger display devices and then, eventually, to ubiquitous display technologies. With this idea in mind, one must consider that there will be a transitional period within which users want to use their existing 2D applications effectively within a 3D environment.

As a result, we propose that 3D user interfaces should satisfy the following criterion:

- they provide not just unique but instead more functionality than existing desktop interfaces
- their interaction scheme is familiar and reinforced by desktop usage
- they use a canonical input device for interaction
- their development only requires adding the functionality unique to 3D environments

We use a combination of Image-Plane and Through-The-Lens techniques to satisfy the above criteria for a broad category of 2D and 3D applications [1]. We base our framework on the idea that the WIMP interaction technique is actually a special case of Image-Plane selection where the viewpoint and cursor distance are fixed and the viewing model is parallel perspective (figure 1). Within this context, the transition between desktop interfaces can occur seamlessly by adding attributes associated with augmented reality. For example, adding a tracked viewpoint allows the user to change the selection point on the interface either by moving their head or by moving the mouse. Moreover, the mouse can be replaced by a 3D mouse at any time by utilizing any one of several transformations between mouse and virtual cursor. Furthermore, stereoscopic viewing can be added at any point during the transition as long as a strategy for disambiguating the cursor referent is used. Finally the finite surface area display can eventually be replaced with a head-mounted or other wide field-of-view display.

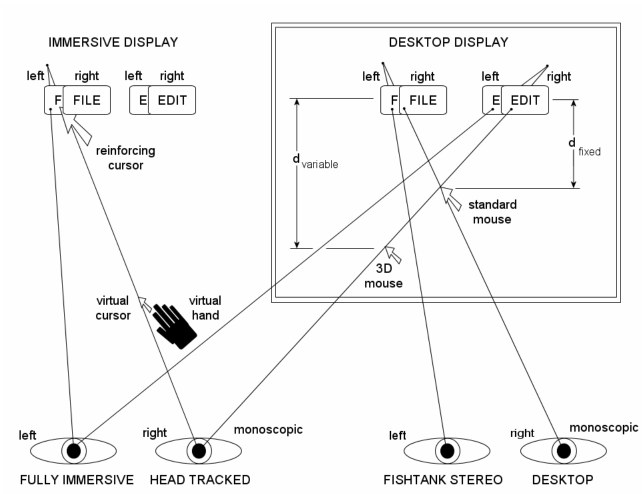

Figure 1: Image Plane as a Bridging Strategy

2 IMAGE PLANE ON 2D VIEWING WINDOWS

Although Ray-Casting has enjoyed steady usage over the years, interaction with cascading menus has proven difficult. One potential reason for this is that, while Ray-Casting is good for point to point motion, its overall transfer function makes it difficult to follow constrained paths presented at the oblique angles that occur as menus cascade away for the user. Image plane selection techniques have the potential to improve menu operation because the direct relationship between the desired path and the virtual cursor reduces the task to one of tracing against the presented image plane.

However, Image-Plane (IP) object selection techniques have two problems that threaten to make them unusable in augmented or virtual reality environments. The first problem is that image plane is associated with significantly higher fatigue levels when used for generalized interaction tasks such as selecting and manipulating objects. Our solution to this problem is to place the 2D interface directly below the hand of the user where the interaction begins to approach that of Ray-Casting. This interaction style is appropriate for interaction with most existing 2D applications that do not interact directly with the environment. Furthermore, a broad class of desktop applications that operate on 3D data can operate effectively in a 3D environment by utilizing Through-The-Lens techniques.

A second problem with IP selection arises because the virtual cursor, usually the virtual or real hand, is at a different depth than the object being selected. As a result, it is not clear which finger in the image plane actually covers the desired object. To resolve this problem, researchers have resorted to using monoscopic display systems, presenting the same image in both eyes [2]. We resolve the problem by placing the virtual cursor in the dominant eye only. The results of user testing have shown that users tolerate this interaction method without increased levels of eye strain or decreased task performance.

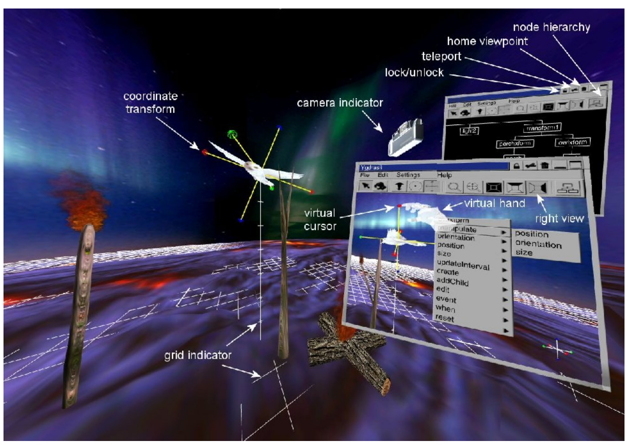

Figure 2: Immersive World Building with Ygdrasil

2 YGDRASIL DEVELOPMENT ENVIRONMENT

As a proof of concept for our framework, we have implemented it in support of a graphical user interface for building virtual works with the Ygdrasil authoring platform developed here at the Electronic Visualization Laboratory. The Ygdrasil platform consists of a distributed shared OpenGL Performer scene graph assembled at runtime by an interpreted scripting language. The platform provides dynamic shared modules ranging from common functions such as transforms, switches, sound and geometry objects to more sophisticated movie texture, particle system and articulated avatars nodes. This application domain is a perfect fit for our framework because the application needs to be available both on the desktop and within an immersive setting (figure 2). By building the application around a viewing window we are able to create both the desktop application and immersive application with a single development effort. The main viewing window encapsulates the selection mode, viewpoint manipulation and scene graph hierarchy functionality found in similar software such as CosmoWorlds and Multigen Creator. A button toggles the window between the viewpoint and a view onto the node hierarchy graph. On the desktop, the viewing window size and position is adjusted dynamically to accommodate resizing of the simulator window. In the immersive setting a camera indicates the location of the window viewpoint.

Creating an alternate viewing window into the environment allows desktop 2 ½D interaction techniques to be implemented on objects within the immersive environment. Three buttons available during immersive interaction provide additional functionality. A teleport button moves the user to the viewpoint shown within the viewing window. A home viewpoint button registers the window viewpoint with the user viewpoint. As a result, any visible object within the scene can easily be captured within the viewing window by pressing the lock/unlock button while the object is within the frame of the viewing window. The viewing window can then be brought back to a comfortable working position below the hand.

In order to take full advantage of 3D tracking, holding the lock/unlock button unlocks the viewpoint and allows hand rotation and distance to directly control the window viewpoint. We have also implemented an IP object manipulation technique that allows objects to be rotated and translated within the working range of the tracked hand.

3 CONCLUSION AND FUTURE WORK

We have shown that image plane techniques can provide a bridging strategy between desktop and immersive user interfaces. We have also shown that previous limitations of Image-Plane selection can be overcome for a broad category of user interfaces in 3D environments by operating on windows below the hand and placing the virtual cursor in the dominant eye of the user. We have also shown that our framework allows applications to be built for both desktop and immersive environments with a single authoring effort. Furthermore, we have described how desktop 3D applications can be enhanced when used in a 3D environment by using novel teleportation, view manipulation, and object manipulation techniques. Our future work will involve an empirical user study to determine if users report similar fatigue levels with windows under hand and perform as well on menu related tasks using IP compared to Ray-Casting.

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